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THE COMMERCIAL EXPLOITATION OF SHRIMP *PALAEMON SERRATUS* (PENNANT) IN IRELAND

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ABSTRACT

Palaemon serratus *is at the northern limit of its range in the British Isles. In ireland it is most abundant in the southwest where it has been commercially fished since the mid-1970s. Landings in recent years have averaged between 200 and300 tonnes annually with an estimated export value of £2—3 m. These landings represent a three-fold expansion over those of the previous decade. The biology of the species was investigated over a 12 month period in Bantry Bay using commercial gear. At most times of the year there is a bimodal length frequency distribution and the life expectancy is interpreted as 2 years. Condition factor does not vary much during the year in males and immature females but the larger females put on up to 30% weight in the autumn. The reproductive cycle in Bantiy resembles that in the south of England rather than that in north Wales, these two locations providing earlier studies of the species. The largest females come into berry in October and egg carriage within the population continues into the following summer; in May, a second group of smaller females, belonging to the 0 age group, carries eggs. Corroborative evidence for this interpretation is provided by the size of the ova and their developmental state. There would appear to be an influx of shrimp to Bantry Bay which builds up from May and declines after January but cohort and gender migrations are unclear. Catch per unit offishing effort (cpue) is estimatedfrom the weight of a consignment of shrimp delivered to aprocessor. Such data are variable but they are also consistent and stable over the short-term and throughout the range of shrimp fisheries. A time seriesfrom 1977 to 1994 suggests a 36% decline; the significance of this is not known. Shrimpfishing takes place during the autumn and winter months. In the southeast landings are taken throughout the year but those outside the periodAugust to January, inclusive, do not exceed 8% of the total. In the southwest only 3% of landings are made outside these months, while in Connemara none was reported Mechanical grading in the factory is explored as a means of reconstructing age profiles. Two patterns of exploitation are described: that of the southwest and southern coast has a larger proportion of 0 group shrimp which may reach 40% by numbers of the total landings; in Connemara the proportion of 0 group shrimp is much smaller. Attempts are made to find some method ofpredicting aspects of the catch from biological and sea temperature data. There is a suggestion that a large brood year is influential in producing a successor whose size is estimated 2 years later. The sustainability of the shrimp fishery is unknown and two precautionary measures are suggested as the basis of a management regime: enlarging the mesh size to improve the exploitation pattern and limiting the fishing season.*

INTRODUCTION

Investigatory work on shrimp was undertaken in Irish waters with a view to its exploitation by Gibson (1959) who surveyed the species along the south and west coasts, and McPadden (1979) who concentrated his efforts on parts of the west. Work byForster(1951 and 1959) andCole (1958) onthe growth and other aspects of the biology of the species in England and Wales revealed regional differences which were attributed to temperature. Similarly detailed work has not hitherto been undertaken in Ireland where a shrimp fishery has been under way since the mid-1970s. Its expansion prompted this appraisal which basis for proposals to manage the fishery.

DISTRIBUTION OF THE SPECIES

Cole (1958) summarised the occurrence of *Palaemon serratus* which ranges from the British
Isles to the Mediterranean basin. In Britain, *Palaemon serratus* is hardly known from the

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coasts of Northumberland and Durham and it is not reported from Scotland. Forster (1951) regarded the Wash as its northern limit; it is fished along the south coast of England as far as Cornwall and to some extent in Milford Haven and around the Welsh coast as far as the Menai Straits. In Ireland, it was recognised to be most abundant in the southwest although it has been reported "sometimes in fair numbers" from Northern Ireland. Its relative abundance is summarised in Fig. 1. The distribution of landings, averaged over 4 recent years illustrates the southerly emphasis in its Irish distribution. Cos. Gaiway (Connemara) and Keny are its stronghold although commercial catches are made on the intervening coastline and along the southern seaboard.

Fig. 1. The distribution of shrimp, *Palaemon serratus*, landings in Ireland and (inset) the relative abundance of

THE **COMMERCIAL FISHERY**

Although there are some pre-1970 references to commercial shrimp fisheries, McPadden (1979) has traced its origin to the southwest coast of Ireland in 1972. Official landings statistics date from the mid-1970s. Figures for shrimp landings from the mid-1970s to 1994 are shown in Fig. 2

which has two phases: until 1989 the fishery progressed at alow level of landings; in 1990 these expanded considerably and have been maintained. It was this expansion which sparked anxiety about the sustainability of the fishery which in turn prompted this investigation. The return of zerc landings in 1985 is regarded as a recording error because shrimp landings were made in that year and are referred to elsewhere in this work. Ti reported landings and value of the fishery in the years 1991—1994, inclusive, are:

Year	Tonnes landed	Value £'000.00	Export £'000.00 (add 40%)
1991	382	1,993	2,790
1992	164	826	1,156
1993	269	1,332	1,865
1994	312	1,591	2,227

A comprehensive account of the expansion of the fishery cannot be provided but the details given to the authors by one fisherman in the southwest (Table 1) may be regarded as an approximation of what is likely to have occurred on a wider scale. His account occupies most of the years in which the fishery has been operational.

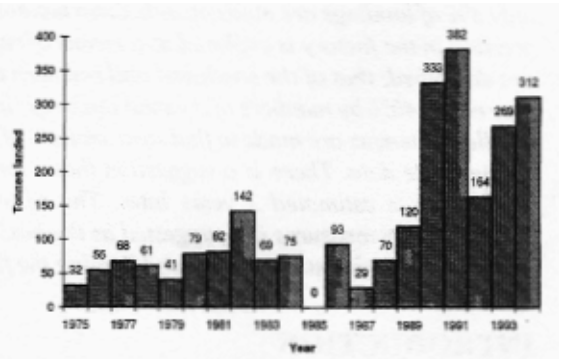

Fig. 2. National landings of shrimp (*Source*: Departm of the Marine).

Since the shrimp fishery got underway in mid-1970s there has been an annual increase in the number of pots fished by the operator. At the same time, technique has evolved and pots are currently being set in the area in question for a shorter fishing time than in the recent past. Supporting the data in Table 1, the number of pots fished in the

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vicinity in 1995 was indeed approximately 300 per boat per day. Landings have fluctuated although whether this was for environmental reasons, the strength of the stock(s) or operational constraints or opportunities is not known. What can be confirmed is that the approximate weight of landings by this fisherman in 1995 also corresponds with the observed landings from the region reported here.

THE INVESTIGATIONS

Work on the shrimp fishery commenced in *1995* along the following lines:

1. In common with most small inshore fisheries, there is little documentation on this one and a search for data was carried out through the books of fish buyers dealing in the trade. A number of companies were visited between March 1995 and March 1996 and relevant data on the purchase of shrimp and their grading were abstracted from their files. The location of these processors, identified as Companies A—G, and the years for which they provided data as well as the length of coastline from which they bought-in shrimp, are set out in Fig. 3.

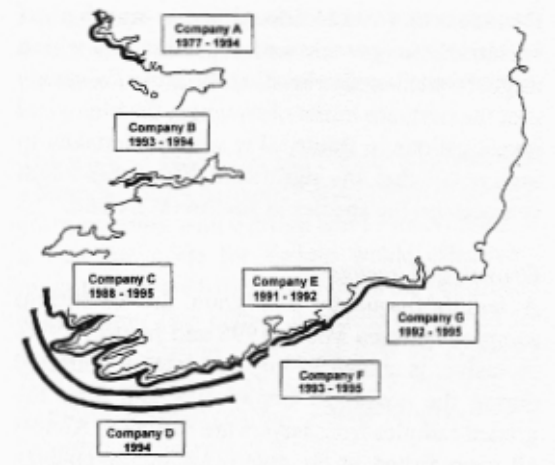

Fig. 3. The location of fish processors from whose records data on shrimp were abstracted, the duration of those records and the adjoining coastline from which landings were bought-in.

The quality of the information collected from buyers, together with the period covered by available records, was variable. Remittance advice notes bearing the date, place of capture and grading of a consignment of shrimp were the basis of a catch per unit of fishing effort (cpue) analysis which, in one instance, constitutes a time series. Consignments of shrimp are graded mechanical screening and factory records of these details were used to reconstruct the composition of the landings.

2. In order to become familiar with the fishery, uie activity of one fisherman fishing out ofGlengariff, was monitored during the season 1995—1996. To ascertain certain features of shrimp biology and to interpret data provided by commercial buyers, four trains each consisting of3O shrimp pots, were set at depths of 1—30 m along the north coast of Bantry Bay on eight occasions throughout the period May 1995—March 1996. The pots were made of black plastic having a mesh opening of 8 mm along one side of a square mesh.

At each fishing, the pots, baited with whiting, were set for 48 h. The content of each pot was stored in a separate plastic bag and transported to cold storage pending examination. After defrosting, shrimp were individually measured from the tip of the rostrum to the base of the spines on the telson, the animal being stretched against a rigid surface and allowance being made for any obvious damage to the tip of the rostrum. For the majority of individuals, the length was recorded to the nearest mm but for some months (September, October, November *1995)* length to the nearest 5 mm was recorded. Forster (1951) had used the larger unit which was later regarded here as too large. Forster had also measured his shrimp live, which was not possible in this case. Cole (1958) used carapace length, from the base of the eye notch to the mid-dorsal hind carapace border as a more reliable indicator of length because of the bend in the shrimp abdomen. Unfortunately, its measurement is also more time consuming and Forster argued against its use on the basis that an error of *0.5* mm in carapace length is likely create more distortion than a similar miscalculation of total length. Forster pointeu ow. that the female carapace is likely to undergo heterogonic growth while the ovary is ripening. Cole (1958) observed that the ratio of length/carapace length is *5.46* in males and 5.22 in females while in larger females it falls to *5.1.* In order to interpret Cole's growth data the total lengths of shrimp taken during the survey in Bantry Bay were correlated with their carapace

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lengths (Fig. 4). The regression equations are given below:

Sex	*r*	*N*	Int	*x*-var
Males	0.92278	50	1.929978	0.92384
Females	0.96659	53	2.16165	0.823733

Calculations of total length from carapace length

Carapace length			*Total length/carapace length*	
(mm)	Male	Female	Male	Female
5	32	34	6.32	6.83
10	58	57	5.80	5.74
15	84	81	5.62	5.38
20	111	104	5.53	5.20

The ratios of total length to carapace length in the case of the Bantiy shrimp is higher than reported by Cole *(1958)* and the ratio decreases inversely with length.

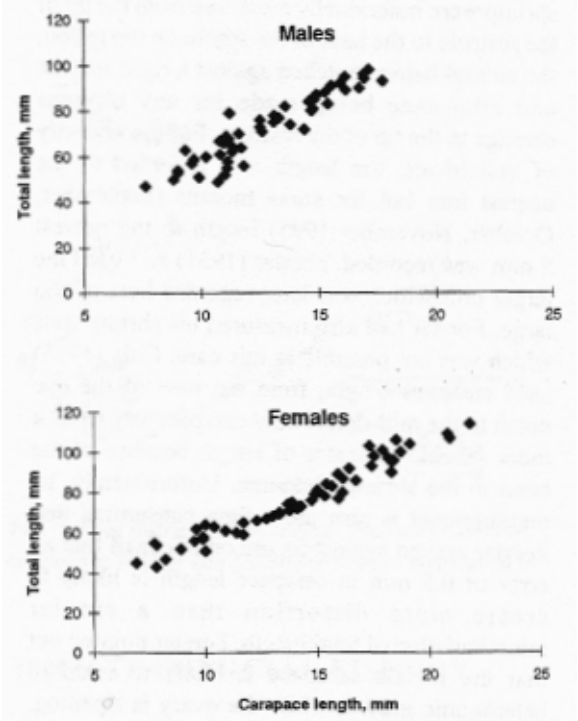

Fig. 4. Regression of total length (from the tip of the rostrum to the base of the spines on the telson) on carapace length (measured from behind the eye to the centre of the hind margin of the carapace) in male and female shrimp.

In addition to length, the weight of each shrimp was recorded. Gender was established on the presence of an *appendix masculina* on the second pleopod. The presence of eggs on the females was noted as was their state of development (eyed) and longest dimension.

3. Samples of graded prawns, packed for sale, were removed from dealers to the laboratory where they were analysed as in 2 above.

The commercial fishing season for shrimp, observed along most parts of the coast, extends from approximately July/August to February/March of the following year. In this analysis some phenomena are treated in terms of a "fishing year": for example cpue in the 1993 fishing season would embrace data from July 1993 to March 1994. Other aspects of the statistics, e.g. the total landings reported annually by the Department responsible for fisheries, are given for a calendar year.

RESULTS

Biological observations

Biological investigations of *Palaemon* by Forster *(1951),* Cole *(1958),* Sollaud (1916) and Desbrosses (1951) identified a number of variations in growth and reproduction which might be attributed to location. Because *Palaemon* is at the northern limits of its range, the biological investigations in Bantry Bay were undertaken to inquire whether any significant differences might characterise the species in southwest Ireland.

Growth and ageing

A length frequency histogram for all shrimp sampled between March 1995 and January 1996, inclusive, is shown in Fig. *5.* Material collected during the census in Bantry Bay and from the graded samples from buyers are included. Almost all were fished in the southwest of the country (approximately 300 were captured in the southeast) using a similar fishing method, plastic pots with a mesh size of 8 mm.

Palaemon serratus metamorphoses at 9 mm. Until it reaches a length of *55* mm it is not retained in the pots in any numbers; hence, the lower part of the histogram is not representative of the abundance of younger shrimp.

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Shrimp cannot be aged by reference to an individual but age might be inferred from length frequency distributions. Basic to that exercise is an approximation of the longevity of the species. Sollaud (1916) believed that shrimp survived for *5* or 6 years. Cole *(1958)* thought it probable that shrimp normally lived for 4 full years. Forster (1951) reckoned that most died in their third summer but he remarked that some large specimens of unknown age were trawled in winter. Cole *(1958)* questioned Forster's interpretation of length frequency data and Forster responded by re-opening the matter in a second paper *(1959)* when he confirmed his earlier findings.

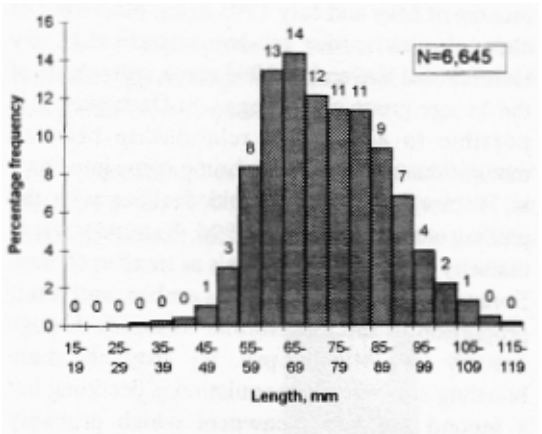

Fig. 5. Length frequency distribution of shrimp captured in commercial pots of mesh size 8 mm along one side of the square, over a 12 month period in southwest Ireland.

The work of both Cole and Forster demonstrated a bimodal length frequency distribution of shrimp, corresponding with 0 group and 1+ individuals. A 2 year life cycle for shrimp would effectively mean there were two age groups in the population at any time. This pattern is indeed confirmed for the Bantry shrimp monitored over an extended fishing season, except in the months of September—November when lengths were recorded at intervals of *5* mm.

Reference to the literature and to the samples collected in Bantry Bay (see Appendix Table), confirms a similar bimodal pattern: females are larger than males of similar age (Fig. 6); growth takes place between July and September, inclusive, after which it slows down until the following year. In the month of July, before the new 0 group has recruited to the fishery, almost all shrimp belong to the 1+ group (Fig. 7). Forster *(1951)* demonstrated that increase in length is confmed to the months of July to November and the example he set out indicated growth in mean length of 1+ shrimp of 65 to 83 mm approximately. The mean length of shrimp belonging to the second length frequency group from Bantry Bay was approximately similar throughout the sampling period and no trend in growth was apparent (Table 2).

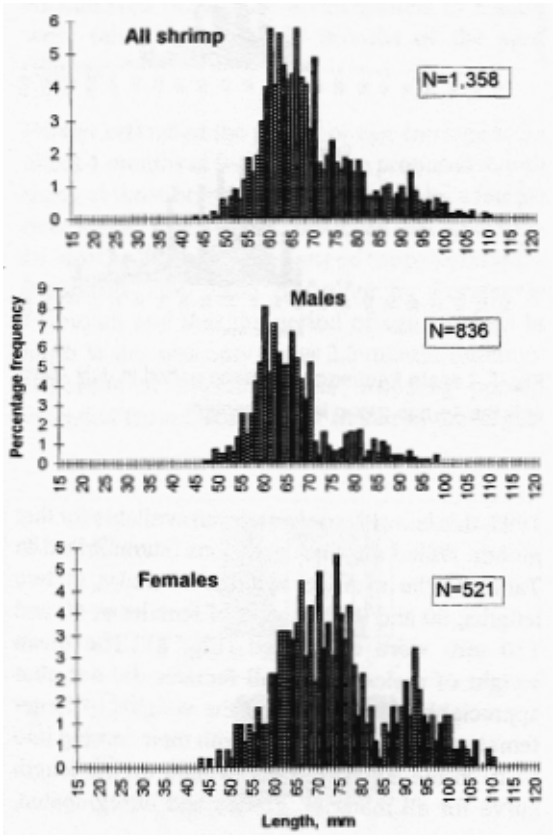

Fig. 6. Bimodal length frequency distribution of shrimp potted in January 1996.

Because there is no way of distinguishing between 0 and 1+ age groups, the two are separated by arbitrarily slicing. Separating the 0 and 1+ groups of either males or females is straightforward (Fig. 6) but, because females grow at a faster rate than males, choosing a slice point for the combined sexes is more subjective. Three are used here: 65, 70 and 75 mm being the lengths at which the age groups are divided.

Condition

Log weight on log length regressions for males and females were calculated for ungraded samples in each month and for graded material in March

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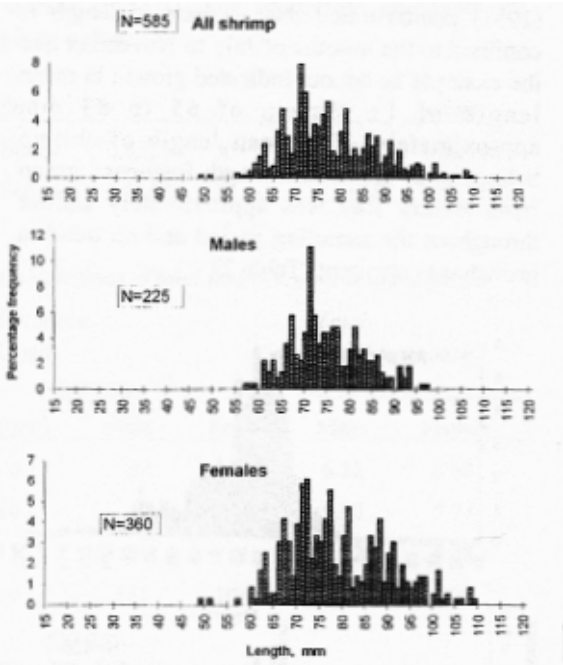

Fig. 7. Length frequency of shrimp potted in July 1995; only the 1+ age group is represented.

1995, this being the only material available forthat month. Based on the regressions (summarised in Table 3) the average weights of males at two lengths, 60 and 90 mm, and of females at 60 and 110 mm were calculated (Fig. 8). The mean weight of males and small females did not alter appreciably throughout but the weights of larger females did, corresponding with their coming into berry in the autumn. A log weight on log length curve for all material, graded and unsegregated, collected between March 1995 and January 1996, inclusive, has the values:

r=0. *96*, *N=6,645*, Intercept=-12.55,
x-variable=3. 14

Using this relationship (which is shown in Fig. 9), the mean weights of 1+ shrimp potted during the 1995 season are given in Table 3.

Maturation and reproduction

There were no berried females in the samples taken during September *1995*, so this month, during which growth is rapid, is a convenient one in which to begin a description of the annual reproductive cycle. In Fig. 10 the sequence of events is presented with this starting date, the months of May and July *1995* being placed out of chronological order to demonstrate this. By October and November 1995 some individuals of the 1+ age group carried eggs. In December, it is possible to ascertain a relationship between maturation and size: some shrimp come into beny at 70 mm and this threshold declines with the passing of time. In January 1996, the trend towards maturity is manifest in animals as small as 60mm. Some ova are eyed in December and their proportion of the total further increases through January into March/April. By May, the main breeding cohort of the population is declining but a second group of spawners which probably consists of 0 group shrimp from the previous year, becomes a significant contributor to the mature component of the population. Forster (1951) considered that shrimp become mature in their 0 year. However, by July they too have largely disappeared and the few remaining ova are eyed.

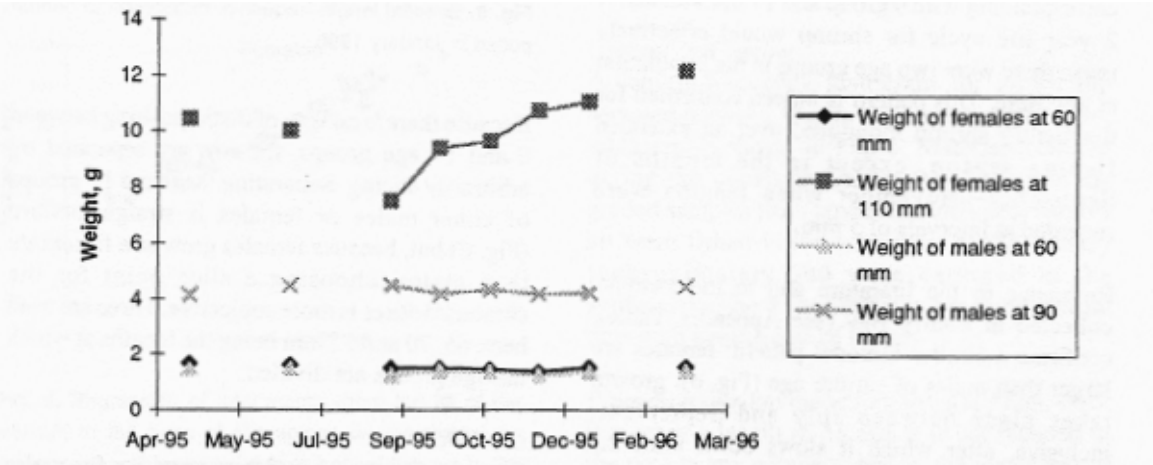

Fig. 8. Calculated weight at selected lengths of male and female shrimp throughout the sampling period from material potted in Bantry Bay.

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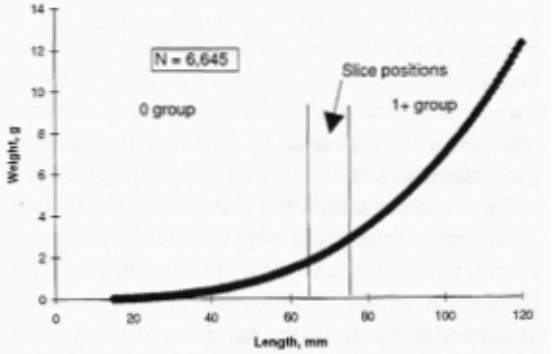

Fig. 9. Relationship between weight and length in shrimp (sexes combined) over the survey period from May 1995 to March 1996. The vertical lines mark the extreme slice points at 65 and 75 mm.

Gibson *(1959)* reported a similar though longer period of egg carriage in Bantry Bay, some shrimp being berried in September.

Earlier spawning has been associated with greater size by Forster *(1951)* who also reckoned that the breeding season lasted from November to June,

the smallest females maturing in March. Further elucidation of the reproductive cycle was provided by the size of and developmental state of the ova. Several workers have remarked on the relationship between egg size and shrimp length and a correlation of these measurements in Bantry shrimp confinns this (Fig. 11 —where r=0.3363, N=834, *P<0.001).* Eggs increase in size over time and eyed ova are larger than those at an earlier stage of development. The smallest eyed ova encountered during the investigations in Bantry were taken in the early months of the year (Fig. 12).

Forster estimated the period of egg carriage to be about 4 months at 9—11°C and he proposed that as many as three broods might be carried by a female over a year. Cole (1958) observed that spawning in north Wales commenced approximately 3 months later than observed by Forster at Plymouth and that the period of egg carriage in north Wales was only about *2.5* months duration. Whereas at Plymouth the breeding period extended from December to March in the largest

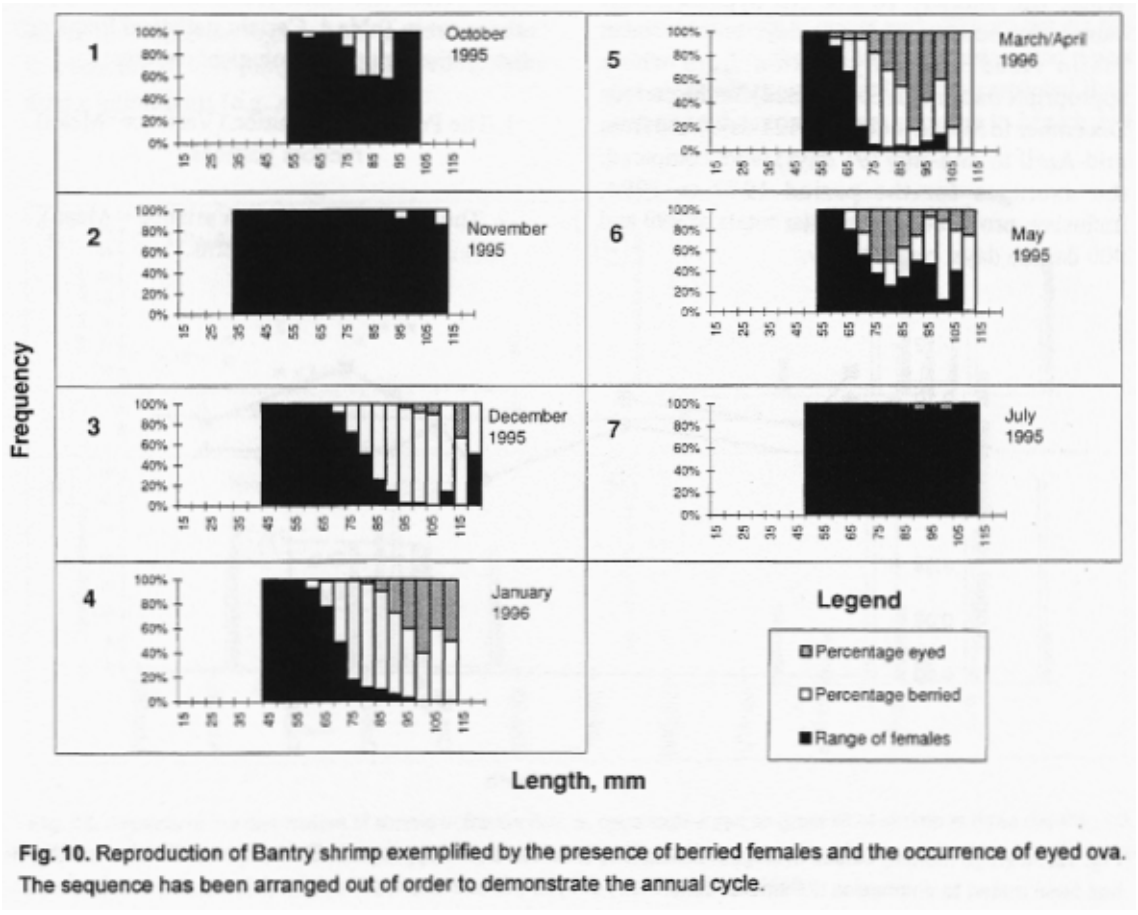

Fig. 10. Reproduction of Bantry shrimp exemplified by the presence of berried females and the occurrence of eyed ova. The sequence has been arranged out of order to demonstrate the annual cycle.

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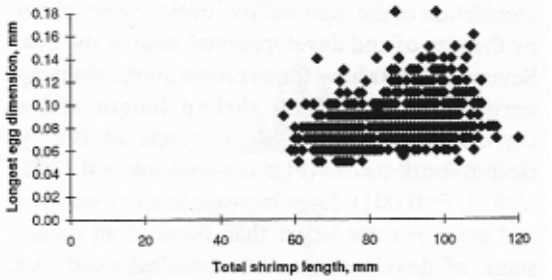

Fig. 11. The relationship between longest ovum dimension and female shrimp length.

breeding shrimp and from March to July in the smallest (roughly corresponding with what has been observed in Bantry), in north Wales it was generally from mid-April to the end of July. Cole attributed the variation to the explanation that temperatures of less than 8°C inhibit spawning. At Plymouth such low temperatures were not reached except for brief periods but in north Wales they delayed the onset of breeding. On the other hand, by pushing the period of egg carriage into the wanner months of the year, its duration in north Wales was shorter. To test this hypothesis, the cumulative number of degree days as recorded at Malin Head (the only station from which appropriate data might be obtained) for the periods December to March inclusive (121 days) and from mid-April to mid-July (91 days) were compared; the averages for the period 1977 to 1994, inclusive, provided very similar totals of 999 and 900 degree days, respectively.

Distribution

Shrimp were sampled along the north coast of Bantry Bay from the shoreline to below 25 m using pots employed in the commercial fishery. The pots were separated by intervals of 10 m and set in trains of usually 30. The yield of any pot was influenced by a number of factors, the abundance of shrimp and the intensity of their feeding activity being two obvious ones. The nature of the dispersion of the animals on the seabed was examined in terms of the numbers of shrimp per pot from two trains in July and two in October 1995 and from four trains in January 1996. For each train the mean numbers per pot were calculated. Variance was estimated by the formula:

$$S^2 = \frac{\sum (fx2) - [\sum (fx)\,2/N]}{N-1}$$

where f is frequency of occurrence, x represents various values of the number of shrimps per pot and N is number of pots.

Mean values and variances for each train of pots are set out in Table 4. Certain statistical frequency distributions suggest ecological patterns:

1. The Poisson distribution (Variance=Mean), random patterns.

2. The positive binomial (Variance <Mean), uniform patterns.

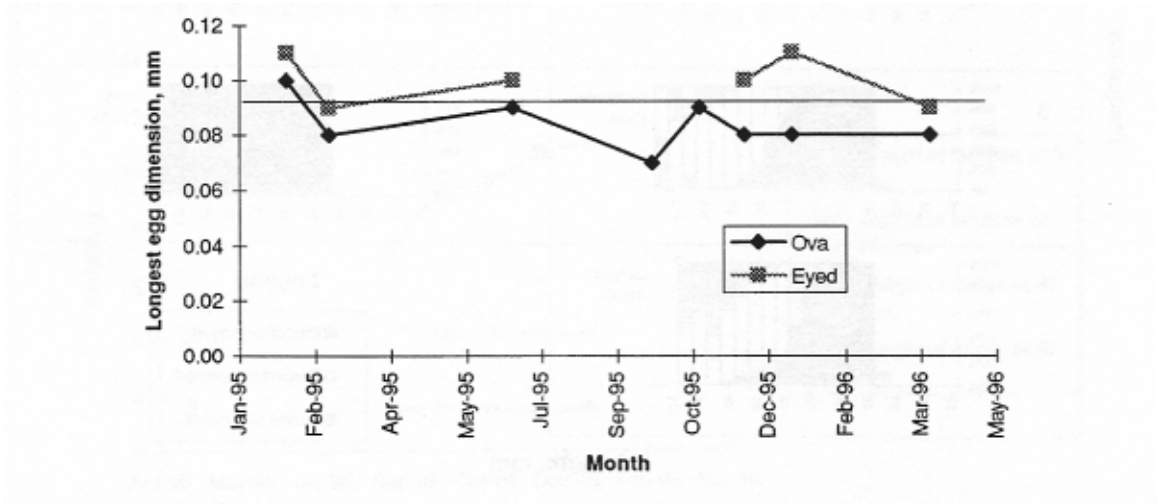

Fig. 12. Average monthly values of longest dimensions of all ova and of eyed ova in Bantry shrimp. The horizontal line has been added to emphasise the smaller dimensions of eyed ova in the spring.

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3. The negative binomial (Variance> Mean), clumped patterns.

The distribution of shrimp in each train of pots was tested for patterns 1 and 2 and most were discounted as random or uniform distributions. However, all showed affmities to the negative binomial indicative of a clumped distribution on the seabed.

Southwood (1966) has given three methods for the calculation of the negative binomial:

$$1.\quad k = \frac{\bar{x}^2}{s^2 - \bar{x}}$$

$$2.\quad \log\left(\frac{N}{n_0}\right) = k \log\left(\frac{1+\bar{x}}{k}\right)$$

where *N* is the the number of samples and *n* is the number of pots containing no animals. Other symbols as in Formula 1.

$$3.\quad N \ln\left(1 + \frac{\bar{x}}{k}\right) = \sum\left(\frac{A_x}{k+x}\right)$$

where In=Napierian logs and *Ax* is the sum ot all frequencies of sampling units containing more than x individuals (e.g. *A6=~f7+fs+fg).*

Formulae 2 and 3 are solved by iteration. Formula 1 provides an approximate value but formulae 2 and 3 give more precise ones. The low values of *k* in all cases (Table 4) indicate an aggregated distribution of the animals on the seabed, probably due to the occasional occurrence of rock cover or algae on a substratum of mud or sand.

Migrations

Shrimp populations were censused using commercial pots fished at three depths, less than 3 m, inshore, greater than 25 m in deep water at the mouth of Bantry Bay, and at intermediate depths of 10—18 m. While these fishings provided evidence of the characteristics of local shrimp populations, they are regarded as unreliable indicators of true numbers. Weather conditions may alter the efficiency of fishing and there is no way of relating yield to population size. With that reservation, the cpue in g per pot fished is given in Fig. 13 where it will be seen that the performance of the fishery improved as the year advanced and then declined.

The work of Forster (1951) suggested that shrimp move onshore in summer and offshore during the winter months. Reeve (1969) remarked that it was not clear why commercial potters restricted their season to the months from October to March and

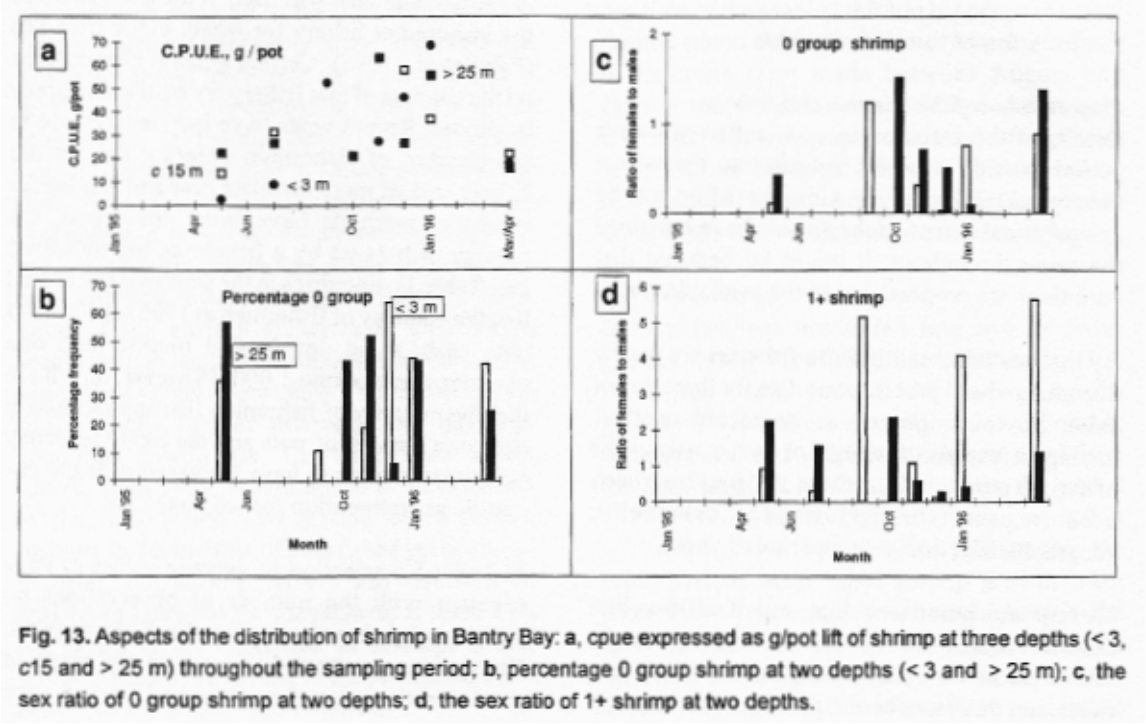

Fig. 13. Aspects of the distribution of shrimp in Bantry Bay: **a**, cpue expressed as g/pot lift of shrimp at three depths (< 3, *c*15 and > 25 m) throughout the sampling period; **b**, percentage 0 group shrimp at two depths (< 3 and > 25 m); **c**, the sex ratio of 0 group shrimp at two depths; **d**, the sex ratio of 1+ shrimp at two depths.

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he supposed that lobster fishing inthe summer was more attractive, which suggests that the annual offshore migration is not a very marked phenomenon. The seasonal movement is thought to be attributable to the fact that shrimp are susceptible to cold conditions (Reeve, 1969).

Aspects of the inshore migration specifically referred to included the abundance of the 0 group close to the shore during the summer months; they disappear in October/November (Reeve, 1969). In Bantry (Fig. 11), the percentage of 0 group shrimp in the entire shrimp population remained fairly constant in the deeper water and, although it declined inshore, 0 group shrimp increased in relative abundance there in December and January. The sex ratio of 0 group shrimp declined during the autumn from a value of> 1 in September but the incidence of 0 group females increased again in January. Seasonal changes in these populations are therefore not clearly or consistently recognisable either because the samples reflected local conditions and abundance (females are for example known to frequent more rocky areas and males muddy places) or because the on/offshore movements are more short-term than seasonal. However, although they must be interpreted with great caution, the cpue expressed as weight of shrimp per pot showed a progressive increase from May until the following January after which they began to decline.

Exploitation of the shrimp stock

Performance of the commercial fisheiy

Details of the variation in cpue collected over a period provide a useful indicator to the way a fishery has performed. Provided that effort and the geographical extent of the fishery have remained the same throughout, it might be deduced that variations are proportional to the available stock.

By their nature small inshore fisheries are poorly documented and precise cpue data for them do not exist. However, processors do record on their buying-in receipts the weight of each consignment of shrimp purchased and these statistics have been used to ascertain performance seasonally, geographically, and over a period of years.

Shrimp are purchased live and it is therefore desirable to sell landings as soon as they are made. Small catches may be amalgamated in holding cages and this must be the practice where shrimp
are sold live to buyers using vivio transport, none of whose records are used in this paper. Shrimp should be held in high density for only a short period because cannibalism greatly reduces their numbers (Cole, 1958) and they are usually transported to sale daily where a fishery is situated close to a buyer. In only a minority of cases encountered in the course of this work would shrimp have been held in storage boxes for a longer period before delivery.

McPadden (1979) used two units of effort when describing an experimental fishery for shrimp in Co. Galway: the number of kg caught per boat per hour and the nett cash returns from 1 h fishing. Sufficiently detailed data were not available to permit the expression of cpue in similar terms here.

The unit of effort used here is the quantity of shrimp (in kg) brought to a processor by a fisherman for which the fisherman receives a docket confirming the delivery. The “journey to buyer” is a crude measurement of cpue because it does not specify the number of man-hours involved in making a landing, nor does it indicate the number of shrimp pots which were set or lifted on the day. It is assumed that the fisherman in question observes a routine which involves much the same quantity of gear over the short-term.

A similar approach was used in the assessment of the inshore pot fishery for whelk in the Irish Sea (Fahy et al., *1995).* Certain general observations on the conduct of that fishery are believed to apply to shrimp. Recent years have seen an increase in the number of fishermen entering the shrimp fishery and, as more compact gear and less labour intensive methods have been developed, the number of pots set by a fisherman has increased (see Table 1). Enquiries in the southwest indicated that the majority of fishermen in *1995* set 200—300 pots each, some double that number and one operator was working 1,000. However, it is likely that the majority of fishermen fish approximately the same number of pots and the likely tendency is for that number to have increased over the last decade as competition for landings rose.

In Table *5* a selection of average values of cpue together with the number of observations on which each is based are given for *5* recent years. Six processors situated throughout the range of greatest shrimp abundance supplied the data; cpue

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data are very variable and standard deviations had approximately the same values as their averages. Taking these figures as an indicator of shrimp yield in recent years, the cpue appears to have remained fairly stable.

The exercise was repeated (Table 6) using data collated by month from five of the sources in 1994, the best documented year for which 2,656 observations were collected. Most of the fishing effort is concentrated on the autumn and winter months but no overall trend is shown within the season. Instead, local weather conditions and particularly the occurrence of water turbulence are reported to be highly influential on the yield of this fishery.

A record of landings and cpue was supplied for the period 1977—1994, inclusive, by Company A (Fig. 14). Its resemblance to the national record (Fig. 2) is noteworthy and the two correlate highly significantly (r=0.84, *N=18*, P<0.001). Thus, the landings recorded by Company A might be interpreted as a microcosm of what has taken place on a national scale. The landings and cpue of Company A are interpreted as having three separate phases. Between 1977 and 1985 the total output appears to have been fairly stable although the cpue slowly declined. In 1986 there was a sharp disimprovement in the performance of the fishery which further deepened the following year. While this might have been the result of a loss of market by the processor in question or an interruption of fishing activity, circumstances suggest it was a collapse in shrimp stocks; at the time fishing effort was continued, although probably at a progressively decreasing intensity, but adequate concentrations of the animals were not located to sustain a regular fishery. In 1988, cpue of the shrimp fisheries in Connemara recovered and landings comparable to those of the pre-collapse phase were made. The following year the landings further increased but the cpue continued downwards. The third phase of this record, from 1989, is interpreted as an extension of the fishery into new ground and a general increase in the number of pots fished per operator; in brief, the shrimp fishery has achieved its maximum potential for the moment at least. This last phase of the expansion in landings is also interpreted as contributing to the perception that a review of the fishery was required.

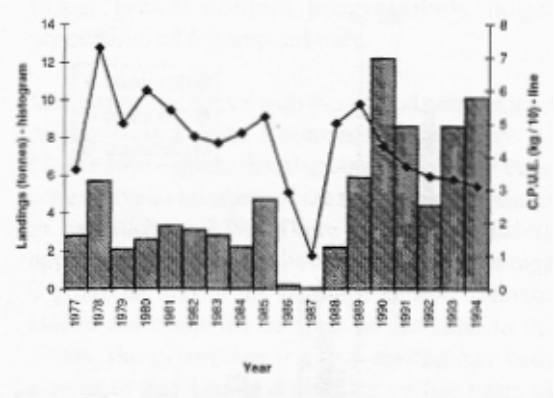

Fig. 14. Annual landings and cpue, expressed as weight of shrimp in units of kg/10 per journey to factory, as abstracted from the records of Company A.

Over the period 1977 to 1994 the cpue has shown a downward trend. Disregarding the years 1986 and 1987, which are regarded as aberrant, the cpue has reduced by 36% (r=0.60, *N—16*, 0.02>P>0.01).

The fishing season

All landings data from the three largest sources, Company A of Connemara, Company C taking landings from Cos. Kerry and Cork (West), and Company G buying in mainly from Cos. Cork (East) and Waterford, are summarised as monthly percentages in Fig. 15 over the period for which records are available. Shrimp may be captured at anytime of the year but this has happened to avery limited extent only in southeast Ireland. The bulk of landings were made between August and January and, even in the case of the southeast, only 8% of shrimp were captured outside this period; in the case of the southwest only 3% were taken between January and August while in Connemara no landings were made outside these months.

Factory grading

Shrimp landings are sorted into five or fewer grades using screens of parallel bars. The percentage contribution to the landings by the grades is related to the time of year, a relationship demonstrated in Fig. 16 which is compiled from the data supplied by Company A for the period 1977—1 994, inclusive, and on the average mnthly sea temperatures from MaIn Head during the same period. Most rapid shrimp growth takes place when sea temperatures are highest in the early autumn. The proportion of grades 0 and 1 increases as the year advances while the smaller grades diminish. The movement of percentage

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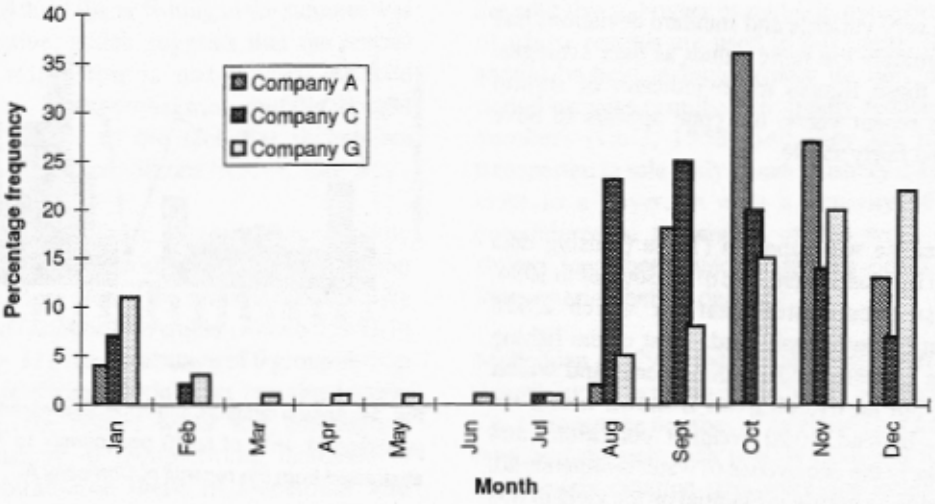

Fig. 15. The monthly percentage frequency distribution of landings to three buyers of shrimp summarised from the duration of their records.

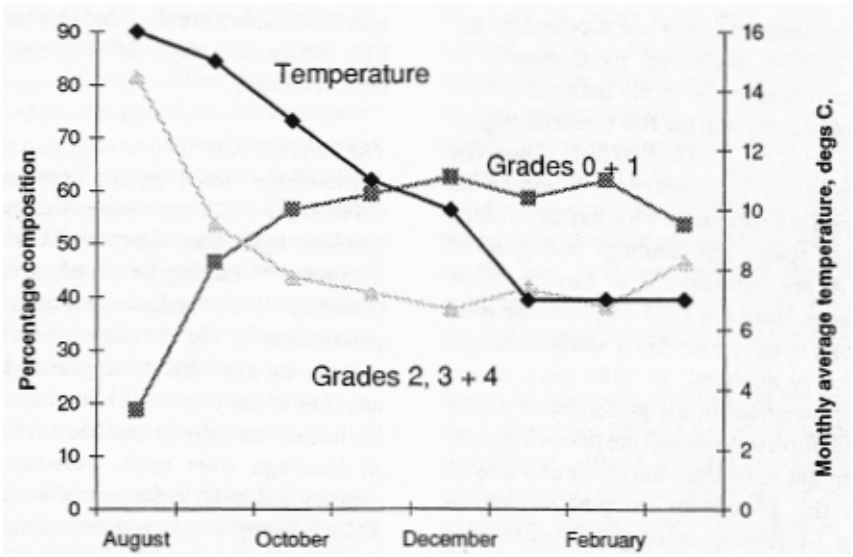

Fig. 16. The allocation of landings bought-in by Company A to grades 0 and 1 and to grades 2, 3 and 4 compared with the monthly average sea temperature at Malin Head. All data have been summarised from 1977 to 1994, inclusive.

landings from grades 2, 3 and 4 to grades 0 and 1 stabilises with the sea temperature in the winter months.

The criteria on which the grades are defined are set out in Table 7. The grading systems of four of the companies whose data are reported here are presented along with one further buyer (Company H) which is not otherwise alluded to. Grading is not sufficiently standardised to enable its definition by any one processor to be used as a method of recognising sectors of the shrimp population from commercial data logged by the industry generally. The settings of the grading bars vary slightly from one dealer to another and the defmition of grades, while approximately the same everywhere, is not identical. An analysis of graded shrimp from several sources is presented in Table 8. The characteristics of the grades which were recorded were the average weight of shrimp, the numbers per kg (a consequence of the average weight) and the percentage females they contained. These, and coefficients of variation for them are given in Table S while in Table 9 similar data are provided for graded samples taken from the same company. For the average weight and

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numbers per kg coefficients of variation in the range 15—25% are common. The percentage of females increases with the average individual size (Fig. 17) until in grade 0 (consisting of shrimp which pass through none of the sorting screens) there are no males. It might be added that during the winter months all shrimp belonging to this grade and to grade 1 are berried.

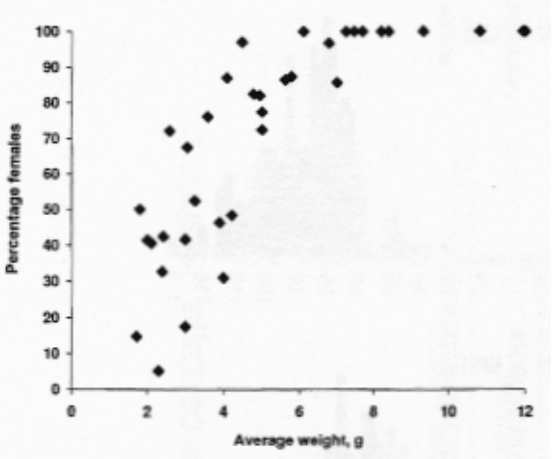

Fig. 17. The relationship between the percentage of female shrimp and their average weight in graded samples.

Conversion: graded weights to shrimp numbers
Fig. 18 presents the length frequencies of the sampled grades, bulked. The animals are divided into age groups by slicing and this is done at three places on the baseline: 65, 70 and 75 mm with the following percentages of samples, expressed as numbers, attributed to the 0 age group:

Sliced at	Grades 0	1	2	3	4
65 mm	0	0	2	18	27
70 mm	0	0	4	29	36
75 mm	1	0	10	42	43

Consideration of the monthly length frequency lata from Bantry might place the slice at any of he above points and 70 mm is probably a good ompromise. However it is interpreted, grades 0 Lnd 1 are almost entirely 1+ shrimp while the three
lower grades contain progressively larger proportions of 0 group animals.

Integrating the above with the graded composition of the record from Connemara (Company A) (Table 10) suggests that 0 group shrimp may be as little as 3% by numbers of the total annual landings or as much as 25%. There is no immediately apparent relationship between the percentage 0 group shrimp in the landings and the tonnage landed and since the increase in the latter in the 1990s, the percentage 0 group shrimp has been similar to that landed during the earlier years of the fishery:

Period	Sliced at 65 mm	70 mm	75 mm
1977–1988	6	9	13
1989–1994	6	9	12

There would appear to be regional differences in the pattern of landings and the percentage contribution of 0 group shrimp to the total as illustrated in Fig. 19. In order to clarif\y the position, the graded landings of three of the fish processors were attributed to age group by slicing. To make the comparison all records of captures have been amalgamated by month for the period
1991—1994.

The contribution of 0 group shrimp to the landings approximately doubles when the slicing point is moved from 65 to 75 mm. In all cases there is a decrease in the percentage of 0 group shrimp between August and September which is probably the result of growth which is rapid in the autumn months. In the case of Company A the decline in the contribution of the 0 group continues into December. Companies A and G buy in similar amounts of 0 group shrimp but the proportion of 0 group animals appears to be considerably greater in Company C and these landings have the most stable age distribution throughout the fishing season.

In the absence of a defmitive explanation for variations in exploitation patterns the heavier exploitation of the younger age group is an obvious one for Company C. That might occur through fishing certain depths or substrata but insufficient is known about the conduct of the

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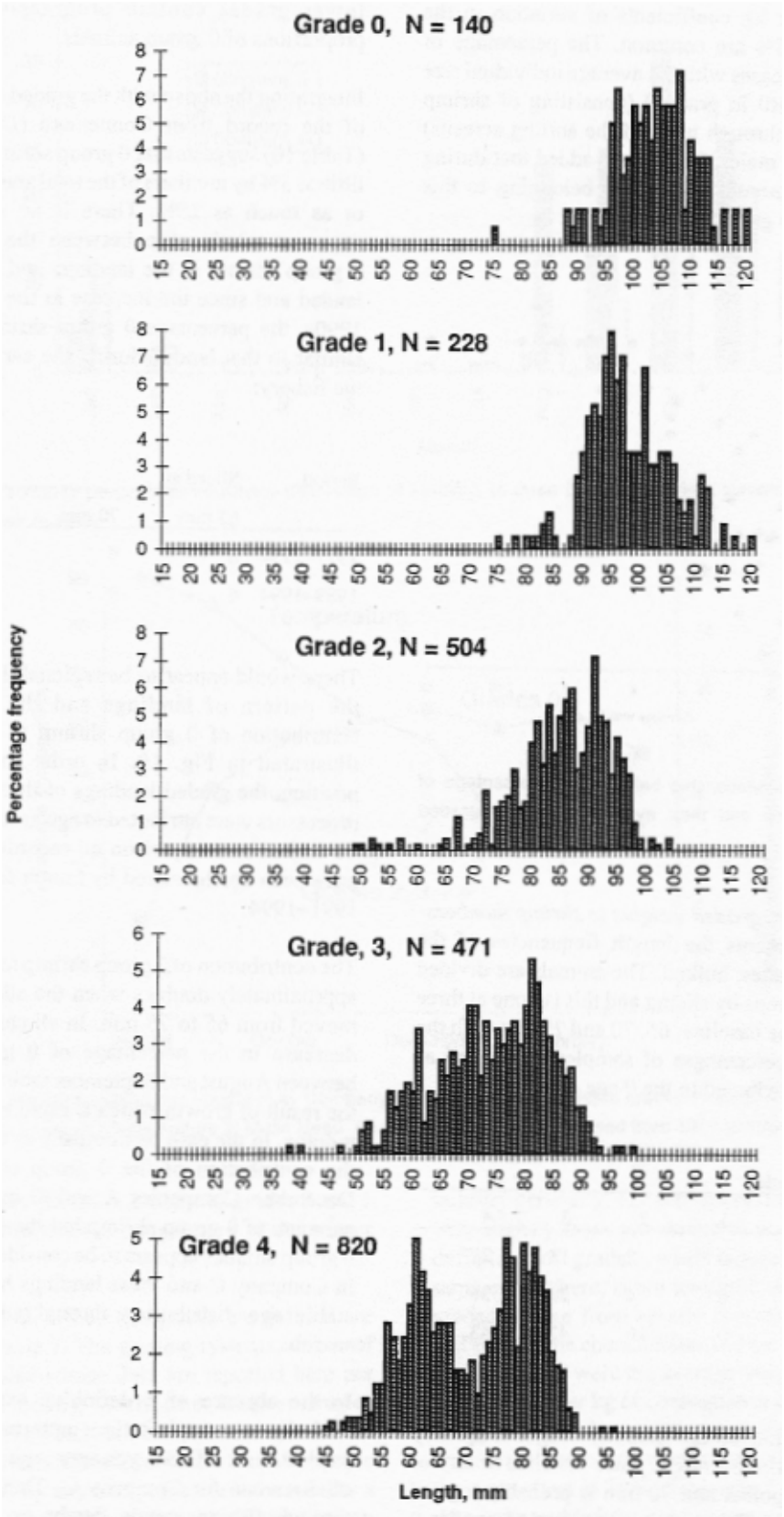

Fig. 18. The length frequency distribution of shrimp in samples from various processors.

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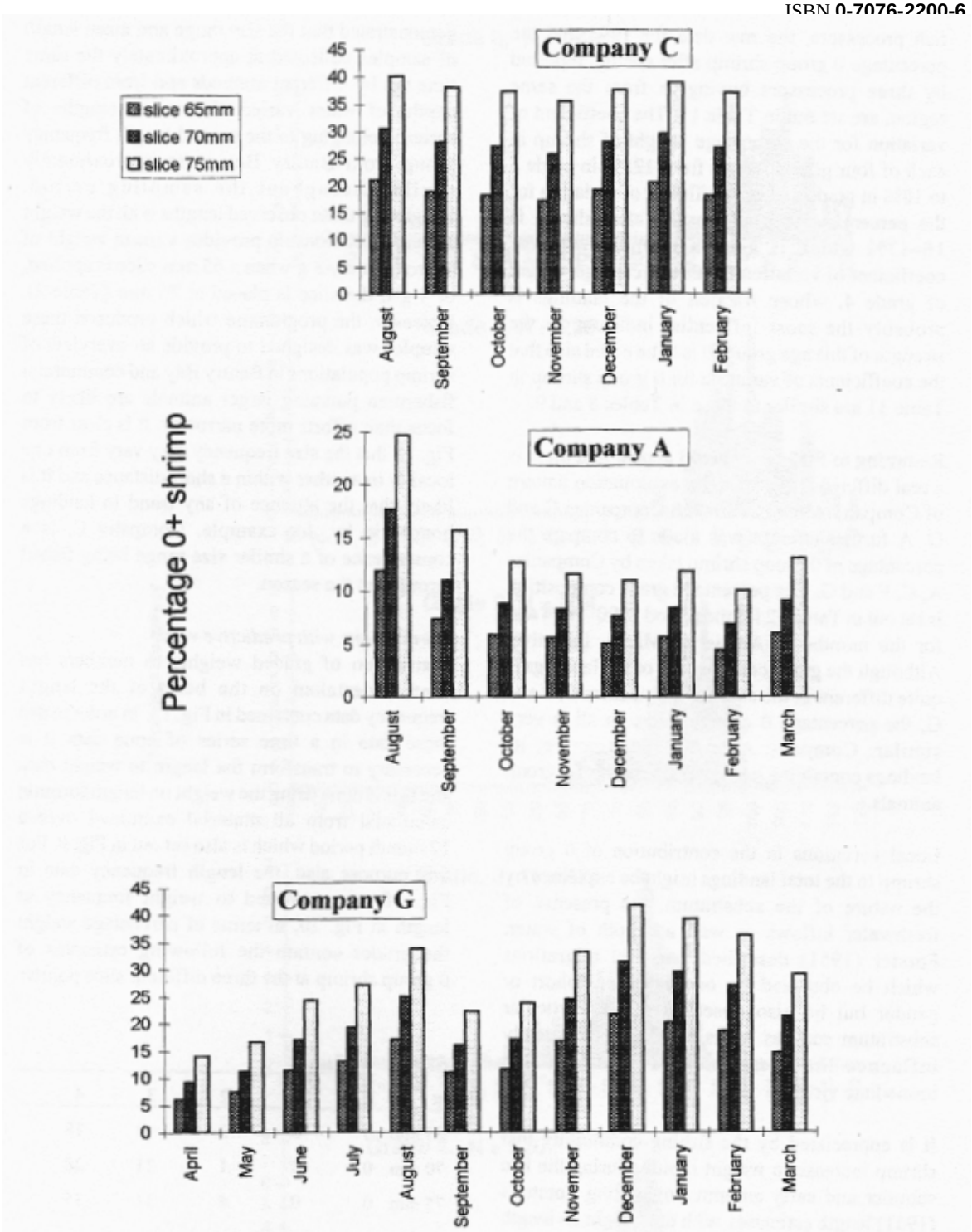

Fig. 19. Percentage 0 group shrimp by numbers in landings to three companies summarised by month for the period 1991 to 1994, approximately. The separation of age groups is by slicing the length frequency distribution at three points, 65, 70 and 75 mm.

fishery nationwide to be certain, or the size distribution may be a consequence of buying-in policy by the dealer in question.

In order to enquire whether the observed differences in the percentage of 0 group shrimp in the landings may be an artefact of grading by the

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fish processors, the raw data for 1994 and the percentage 0 group shrimp after slicing, reported by three processors buying in from the same region, are set out in Table 11. The coefficient of variation for the percentage weight of shrimp in each of four grades ranges from 125% in grade 1 to 18% in grade 4. The coefficient of variation for the percentage 0 group shrimp after slicing is 16—17% which is good agreement with the coefficient of variation for the percentage weight of grade 4, whose fraction of the landings is probably the most influential indicator to the strength of this age group. It is to be noted also that the coefficients of variation for 0 group shrimp in Table 11 are similar to those in Tables 8 and 9.

Returning to Fig. 19, it would appear that there is a real difference between the exploitation pattern of Company A compared with Companies C and G. A further attempt was made to compare the percentage of 0 group shrimp taken by Companies A, C, F and G. The percentage grade composition is set out in Table 12 for the period 1990—1 994 and for the months of August to March, inclusive. Although the grade composition of the landings is quite different in the cases of Companies C, F and **G, the percentage 0 group** shrimp in all is very similar. Company A is quite distinctive, its landings containing a small proportion of 0 group animals.

Local variations in the contribution of 0 group shrimp to the total landings might be explained by the nature of the substratum, the presence of freshwater inflows as well as depth of water. Forster (1951) described seasonal migrations which he observed by one or other cohort or gender but he also observed that a particular substratum such as rocks or mud could greatly influence the occurrence of shrimp in the immediate vicinity.

It is appreciated by the fishing community that shrimp increase in weight rapidly during **the late** summer and early autumn. Integrating Forster's (1951) length estimates with the weight on length regression for all shrimp sampled over a year (Fig. 9), suggests an increase in weight of from 1.3 to 3.8 g, a rise of 192% in individual weight over a period of from 4 to *5* months.

The local distribution of shrimp is aggregated and the nature of the aggregations is likely to be influenced by the habitat. Forster *(1951)* demonstrated that the size range and mean length of samples collected at approximately the same time but by different methods and from different depths of water varied. The mean lengths of shrimp belonging to the second length frequency group from Bantry Bay were approximately similar throughout the sampling period. Integrating these observed lengths with the weight at length relationship provides a mean weight of approximately 3 g when a 65 mm slice is applied, or 4 g if the slice is placed at 75 mm (Table 2). However, the programme which produced these samples was designed to provide an overview of shrimp populations in Bantry Bay and commercial fishermen pursuing larger animals are likely to focus their efforts more narrowly. It is clear from Fig. 13 that the size frequency may vary from one locality to another within a short distance and it is likely that the absence of any trend in landings bought in by, for example, Company C, is a consequence of a similar size range being fished throughout the season.

Correlations with predictive value

Conversion of graded weights to numbers has been undertaken on the basis of the length frequency data contained in Fig. 18. In order to use these data in a time series of cpue data it is necessary to transform the length to weight data and this is done using the weight on length formula calculated from all material examined over a 12 month period which is also set out in Fig. 9. For this purpose also, the length frequency data in Fig. 18 are converted to weight frequency at length in Fig. 20; in terms of percentage weight the grades contain the following estimates of 0 group shrimp at the three different slice points:

Sliced	Grades				
at	0	1	2	3	4
65 mm	0	0	0	9	18
70 mm	0	0	1	21	28
75 mm	0	0	4	31	35

The only data series suitable for examination for its predictive value is the record of Company A for the period 1977—1 994 (excluding 1986 and 1987). The cpue data were used to indicate the weight of shrimp caught by a fishing unit per journey to sale and the details of shrimp graded in the factory

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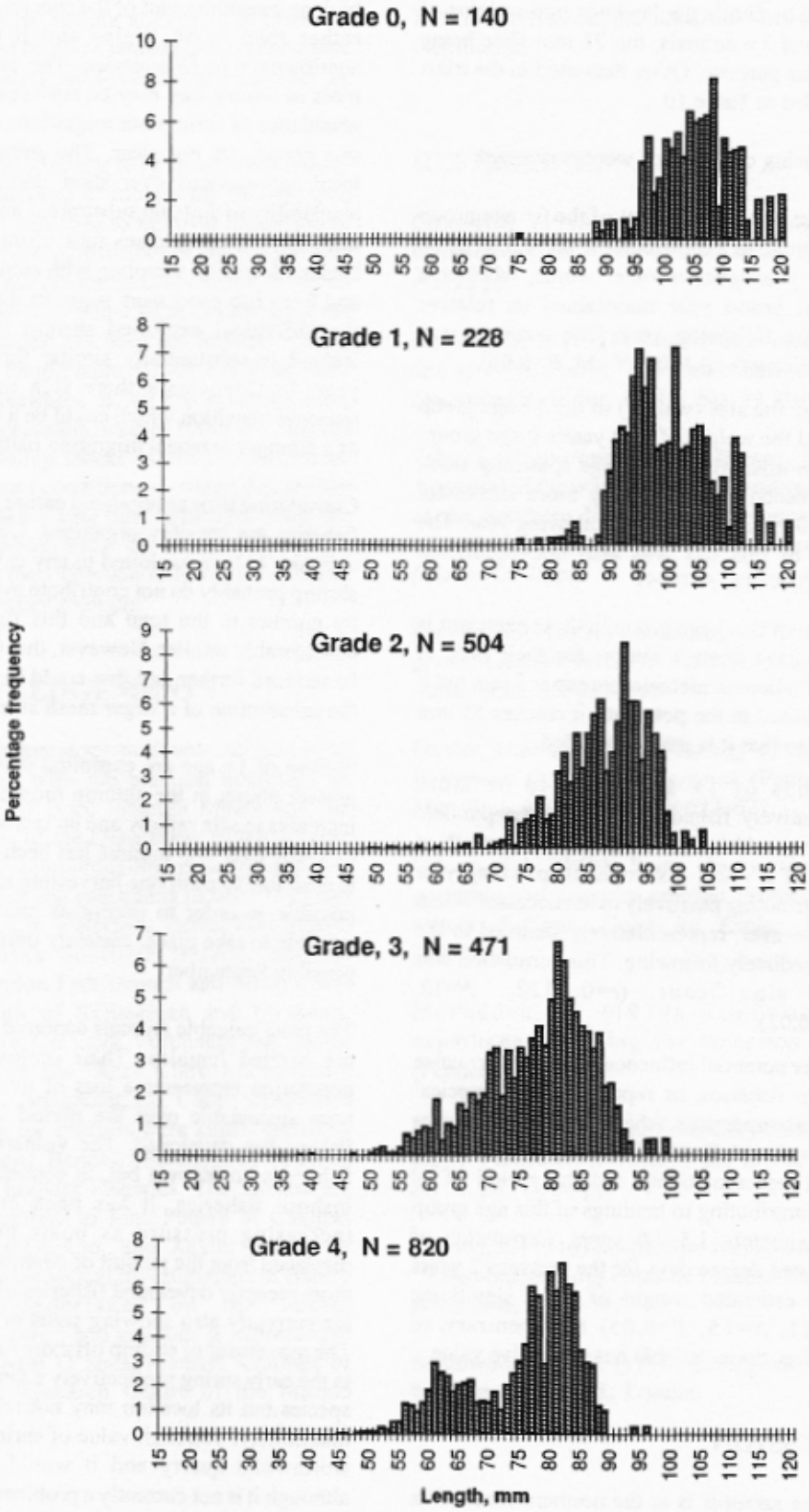

Fig. 20. Conversion of the percentage length frequency distributions in Fig. 18 to percentage weight at length frequencies of the same samples.

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were used to divide the landings into weights of 0 group and 1+ animals, the 75 mm slice being used for the purpose. Other data used in the trials are included in Table 10.

The following correlations were performed:

1. Whether the size (weight) of the 0+ age group was influential as a contributor to the weight of 1+ shrimp 1 year later; in other words, whether a successful brood year maintained its relative success the following year. The outcome was non-significant (r=0.1601, *N=14*, P>0.05).

2. Whether the size (weight) of the 1+ age group influenced the weight of next year's 0 age group; in other words, whether a large spawning stock was succeeded by a relatively more successful group of 0 group shrimp the following year. The outcome of this test was also non-significant (r=0.2203, N=14, P>0.05).

Defmition of the 0 age group in these exercises is likely to have been a reason for their lack of success. *Palaemon* metamorphoses at 9 mm but it is not retained in the pots until it reaches *55* mm in length so that it is poorly sampled.

3. Shrimps of 1+ are likely to be more representatively fished and an obvious possible relationship within this cohort is its strength at intervals of 2 years, a successful spawning year class contributing positively to its successor which is not, however, representatively sampled in the year immediately following. This correlation was indeed significant *(r=0* .6522, N=12, *0.05>P>0.02).*

4. Another potential influence on the performance of shrimp fisheries, as reported of the species' growth, is temperature, which is here expressed as degree days at Malin Head. Only the 1+ year class is fished representatively and the period of its growth contributing to landings of this age group is approximately *1.5—2.0* years. Correlation of accumulated degree days for the previous 2 years with the estimated weight of 1+ is significant *(r=0.561* 1, N=l5, *P<0.05)* but, contrary to expectation, the x-variable has a negative value.

DISCUSSION

Palaemon serratus is at the northern limit of its range in the British Isles and its biology over a short distance may be variable. In Bantry Bay its biology resembles that of the species at Plymouth rather than north Wales and it might alter significantly in Connemara. The results of pot trials in Bantry Bay may be representative of the abundance of shrimp but migrations of age group and gender are not clear. The animal occurs in local aggregations over short distance and the availability of suitable substratum and cover may influence the age and sex ratio of the population. Data collected by sampling with commercial gear and from fish processors suggests that the size of the individual exploited shrimp in southwest Ireland is substantially similar throughout the year. In Connemara there is a more marked seasonal transition which could be a consequence of a stronger seasonal migration pattern there.

Considering their unregulated nature, Irish shrimp fisheries are sensibly organised. Only the older animals (1+) are exploited to any extent; 0 group shrimp probably do not contribute more than 40% by number to the total and this figure may be considerably smaller. However, that figure should be reduced further and that could be achieved by the substitution of a larger mesh size on the pots.

Shrimp of 1+ age are exploited during their last growth phase; in the autumn months the species increases in size rapidly and an increase in weight of 190% over *4—5* months has been estimated. It is desirable to postpone harvesting until as late as possible in order to permit as much growth as possible to take place, certainly until August and possibly September.

The most valuable animals captured in the winter are berried females. Their removal from the population represents a loss of ova but this has been sustainable over the period in which this fishery has developed. The vulnerability of the fishery is not known but, in common with other inshore fisheries, it has been coming under increasing pressure as boats have become displaced from the pursuit of other traditional and more recently developed fisheries offshore which are currently also showing signs of over-fishing. The movement of shrimp offshore to deeper water in the early spring is effectively a sanctuary for the species but its location may not remain a secret indefinitely. The high value of shrimp makes it a worthwhile quarry and it would be better –although it is not currently a problem because very few fishermen pursue shrimp outside the traditional autumn—winter season — to set a

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finishing date for fishing activity; it is proposed that this should be early January. An opening date of approximately mid-August should also be considered.

It would also be desirable to establish some fishery independent method of monitoring this species; cpue has been observed to fall over the period of the fishery but the significance of this observation is not known, nor are the natural conditions which regulate the species. Some weak evidence for the size of broodstock has been put forward but the influence of temperature which has been well established elsewhere is, on the available data, contrary to expectation. Reeve (1969)—citing the collapse in shrimp stocks in 1962/63, which he attributed to cold conditions – stated that shrimp populations take a long time to recover while the virtual disappearance of the species from Connemara in the 1980s was followed by a prompt return to its earlier strength.

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Table 1. The development of the shrimp fishery as instanced by one fisherman in southwest Ireland

Year	Number of pots fished	Days per lift	Pots lifted per day	Landings (kg/100 pots)	kg/pot/day	kg per day's fishing
1978	100	1.5	67	60.0	0.60	40
1979	150	1.5	100	60.0	0.60	60
1980	300	1.5	200	2.5	0.03	5
1981	350	1.5	233	8.5	0.09	20
1982	400	1.5	267	8.5	0.09	23
1983	450	1.5	300	40.0	0.40	120
1984	500	1.5	333	15.0	0.15	50
1985	550	1.5	367	15.0	0.15	55
1986	600	1.5	400	12.5	0.13	50
1987	700	1.5	467	12.5	0.13	58
1988	800	1.5	533	12.5	0.13	67
1989	800	3.0	267	37.5	0.38	100
1990	800	3.0	267	37.5	0.38	100
1991	800	2.5	320	17.5	0.18	56
1992	800	2.5	320	17.5	0.18	56
1993	800	2.5	320	17.5	0.18	56
1994	800	2.5	320	17.5	0.18	56

Table 2. Average length of shrimp greater than 65 and 75 mm taken by pots in Bantry Bay during the survey from May 1995 to January 1996 inclusive, and the average weight of captures estimated using the weight on length regression for all samples

	Av. length (mm)	SD	Number	Weight (g)
Greater than 65 mm				
May	80.2	9.9	264	3.4
July	78.7	9.4	543	3.2
September	78.6	8.1	492	3.2
October	72.9	8.2	210	2.5
November	77.6	10.9	706	3.0
December	81.6	10.7	1028	3.6
January	75.8	10.1	800	2.8
March	78.6	10.6	462	3.2
Greater than 75 mm				
May	85.4	7.3	180	4.1
July	84.6	7.7	321	4.0
September	81.6	6.6	384	3.6
October	81.3	6.6	84	3.5
November	84.6	8.6	421	4.0
December	86.9	7.8	727	4.3
January	85.3	8.2	346	4.1
March	86.9	7.9	242	4.4

Table 3. LnWeight: LnLength regressions for shrimp sampled in 1995 and 1996

Month	Females				Males			
	r	*N*	Int	*x*-var	*r*	*N*	Int	*x*-var
May-95	0.98	43	-11.87	3.02	0.96	55	-10.16	2.57
July	0.97	308	-11.78	3.00	0.95	205	-10.73	2.72
September	0.85	409	-10.40	2.64	0.92	99	-12.57	3.13
October	0.92	166	-11.91	3.01	0.82	86	-10.62	2.68
November	0.98	402	-12.39	3.12	0.93	583	-11.28	2.83
December	0.97	275	-13.56	3.39	0.97	887	-11.85	2.95
Jan-96	0.98	520	-12.98	3.27	0.96	836	-11.34	2.84
March	0.98	426	-13.48	3.40	0.97	229	-11.31	2.85

Table 4. Details of catches from eight selected trains of shrimp pots in Bantry Bay and the calculation of *k* values

SUMMARY	
Total shrimp numbers	3085
Total pots	237
Pots with 0 shrimp	65
Pots with 1 or more shrimp	172
Shrimp per pot	13.02

DETAILS								
Pot train	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Date	17 Jul 95	17 Jul 95	23 Oct 95	23 Oct 95	30 Jan 96	30 Jan 96	30 Jan 96	30 Jan 96
Number of pots per train	30	30	29	26	26	30	32	34
Total number of shrimp	86	335	697	253	253	230	712	519
Mean number of shrimp per pot	2.87	11.17	24.03	9.73	9.73	7.67	22.25	15.26
Variance of shrimp per pot	19.64	198.01	237.25	185.72	69.88	91.26	1059.23	348.02

The calculated values of *k* using methods 1– 3 of Southwood (1966)

k1	0.49	0.67	2.71	0.54	1.57	0.7	0.48	0.7
LHS	0.398	0.331	1.462	0.269		0.523	0.551	0.753
RHS	0.398	0.331	1.463	0.269		0.523	0.551	0.753
Difference	0.000	0.000	0.000	0.000		0.000	0.000	0.001
k2	0.47	0.19	1.07	0.15		0.4	0.29	0.5
LHS	59.089	116.484	73.123	104.155	48.385	85.344	132.364	112.061
RHS	59.089	116.484	73.123	104.155	48.385	85.344	132.364	112.061
Difference	0.000	0.000	0.000	-0.001	0.000	0.001	0.000	0.000
k3	0.46	0.23	2.1	0.18	1.79	0.47	0.36	0.59

Table 5. Annual cpue data (kg per journey to buyer) from five sources for the years 1991–1995 inclusive. Location of sources shown in Fig 3

	1991		1992		1993		1994		1995	
	Ave	No	Ave	No	Ave	No	Ave	No	Ave	No
Company A	37	224	34	121	33	272	31	69		
Company B					61	39	37	62		
Company D							28	438		
Company F					26	931	20	1359	24	128
Company E	41	203	23	532	14	130				
Company G			25	1148	30	1398	28	728	26	481
AVERAGE	**39**		**25**		**29**		**24**		**25**	

Table 6. Monthly cpue data (kg per journey to buyer) from five sources for the year 1994. Location of sources shown in Fig 3

Source		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Entire year
Company A	Ave	53								48	25	24	29	**31**
	No	10								5	25	20	9	**69**
Company B	Ave	51	62	60						25	13	21	32	**37**
	No	13	10	3						2	5	17	12	**62**
Company F	Ave								22	18	20	19	23	**20**
	No								241	349	297	297	175	**1359**
Company D	Ave								27	24	28	25	36	**28**
	No								70	54	153	97	64	**438**
Company G	Ave	30	24	51	43	29		16	22	19	21	38	28	**28**
	No	112	39	15	9	3		25	76	90	111	175	73	**728**
Monthly averages		34	32	53	43	29		16	23	19	22	26	27	

Table 7. Criteria by which shrimp are graded according to various dealers

Purchaser	Grade description	Pieces per kg Minimum	Pieces per kg Maximum
Company H	1	0	150
	2	150	220
	3	220	320
	4	320	
Company C	0	1	120
	1	120	200
	2	200	300
	3	300	
Company F	1	0	120
	2	120	280
	3	180	300
	4	300	
Company D	0	50	100
	1	100	150
	2	150	250
	3	250	350
	4	350	450
Company E	1	100	120
	2	120	150
	3	150	200
	4	200	300

Table 8. Details of graded shrimp from samples provided by processors

Date	Origin	Grade	Av Wt (g)	Nos/kg	% Female
25/01/96	Company C	0	12	84	100
22/10/95	Company C	0	12	84	100
14/12/95	Company C	0	11	92	100
	Average values for Grade 0		12	87	100
	Coefficient of variation		5	5	0
15/12/95	Company G	1	9	107	100
15/03/95	Company C	1	8	120	100
04/09/95	Company C	1	8	122	100
05/09/95	Company F	1	8	131	100
14/12/95	Company C	1	7	134	100
15/10/95	Company F	1	7	138	100
22/10/95	Company D	1	7	148	97
25/01/96	Company C	1	6	163	100
22/10/95	Company C	1	6	172	88
21/01/96	Company D	1	6	177	86
	Average values for Grade 1		7	141	97
	Coefficient of variation		17	17	6
15/12/95	Company G	2	7	142	86
25/01/96	Company C	2	5	199	72
14/12/95	Company C	2	5	199	78
15/10/95	Company F	2	5	202	82
22/10/95	Company D	2	5	209	83
05/09/95	Company F	2	5	221	97
21/01/96	Company D	2	4	236	48
04/09/95	Company C	2	4	246	87
15/03/95	Company C	2	4	251	31
22/10/95	Company C	2	4	259	46
	Average values for Grade 2		5	216	71
	Coefficient of variation		19	16	30
05/09/95	Company F	3	4	279	76
15/10/95	Company F	3	3	308	52
14/12/95	Company F	3	3	328	67
22/10/95	Company D	3	3	331	17
21/01/96	Company D	3	3	333	42
15/12/95	Company G	3	2	412	42
14/12/95	Company C	3	2	418	33
15/03/95	Company C	3	2	433	5
04/09/95	Company C	3	2	510	41
22/10/95	Company C	3	2	561	50
25/01/96	Company C	3	2	582	15
	Average values of Grade 3		3	409	40
	Coefficient of variation		24	26	54
05/09/95	Company F	4	3	380	72
15/10/95	Company F	4	2	473	41
14/12/95	Company F	4	2	503	23
15/12/95	Company G	4	2	549	33
21/01/96	Company D	4	2	665	9
22/10/95	Company D	4	2	676	28
	Average values for Grade 4		2	541	34
	Coefficient of variation		22	21	62

Table 9. Variation in certain characteristics of shrimp grades from the same source

Date	Origin	Grade	Av Wt (g)	Nos/kg	% Female
15/03/95	Company C	1	8	120	100
04/09/95	Company C	1	8	122	100
14/12/95	Company C	1	7	134	100
25/01/96	Company C	1	6	163	100
22/10/95	Company C	1	6	172	88
Coefficient of variation			**17**	**17**	**6**
25/01/96	Company C	2	5	199	72
14/12/95	Company C	2	5	199	78
04/09/95	Company C	2	4	246	87
15/03/95	Company C	2	4	251	31
22/10/95	Company C	2	4	259	46
Coefficient of variation			**13**	**13**	**37**
14/12/95	Company C	3	2	418	33
15/03/95	Company C	3	2	433	5
04/09/95	Company C	3	2	510	41
22/10/95	Company C	3	2	561	50
25/01/96	Company C	3	2	582	15
Coefficient of variation			**15**	**15**	**65**
05/09/95	Company F	3	4	279	76
15/10/95	Company F	3	3	308	52
14/12/95	Company F	3	3	328	67
Coefficient of variation			**8**	**8**	**18**
05/09/95	Company F	4	3	380	72
15/10/95	Company F	4	2	473	41
14/12/95	Company F	4	2	503	23
Coefficient of variation			**15**	**14**	**55**

Table 10. A time series of cpue data from Company A; the accumulated degree days are sea temperatures from Malin Head. Landings per fishing unit per journey to sale have been allocated on the basis of a 75 mm slice and converted to weight

Year	Accumulated degree days	cpue (kg)	Percentage 0 group (75 mm slice)	Weight of 0 group (kg)	Weight of 1 + (kg)
1977	3712	36	8	3	33
1978	3737	73	5	4	69
1979	3597	50	9	5	46
1980	3832	60	6	4	56
1981	3818	54	10	5	49
1982	3762	46	9	4	42
1983	3829	44	10	4	40
1984	3848	47	20	9	38
1985	3679	52	13	7	45
1986	3521	0	6	0	0
1987	3704	0	0	0	0
1988	3869	50	7	4	47
1989	4048	56	16	9	47
1990	4016	43	8	3	40
1991	3895	37	7	3	34
1992	3965	34	4	1	33
1993	3809	33	13	4	29
1994	3927	31	6	2	29

Table 11. Percentage grade composition of shrimp landings purchased by three buyers from four areas of southwest Ireland in 1994 with estimates of the percentage 0 group animals and coefficients of variation of the percentages and for the grade composition

Company	Area	Grade 1	Grade 2	Grade 3	Grade 4	Total landings (*t*)	Slice 65 mm	Slice 70 mm	Slice 75 mm
Company C	Skibbereen/Bantry	1	14	58	27	39	18	27	37
Company D	Skibbereen/Bantry	6	33	28	33	3	15	21	29
Company F	Skibbereen/Bantry	14	24	23	39	17	15	22	29
Company C	Glengariff/Castletown	1	13	48	38	17	19	28	38
Company C	South Kerry	1	15	52	32	10	18	27	37
Company F	South Kerry	21	30	23	26	6	12	17	24
Company C	North Kerry	1	16	58	25	6	18	26	37
Coefficient of variation		**125**	**40**	**39**	**18**		**16**	**17**	**17**

Table 12. The total landings to four purchasers of shrimp graded for the period of approximately 1990 to 1994 with the estimated percentages of 0 group animals in the totals. Only landings taken in the period August to March are included

Source	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4	Landings (*t*)	Slice 65 mm	Slice 70 mm	Slice 75 mm
Company F	0	15	28	24	33	45	14	20	27
Company C	0	1	13	51	36	32	19	28	38
Company G	0	8	22	33	37	78	16	24	32
Company A	5	51	21	15	8	23	5	8	12

Appendix Table: Percentage length frequencies of all male and female shrimp in samples collected between May 1995 and March 1996

Length	All shrimp								Males								Females							
cm	May	July	Sept	Oct	Nov	Dec	Jan	Mar	May	July	Sept	Oct	Nov	Dec	Jan	Mar	May	July	Sept	Oct	Nov	Dec	Jan	Mar
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
45	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	5	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
50	0	0	0	0	4	0	0	0	0	0	2	1	3	0	0	0	0	0	0	0	5	0	0	0
51	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
52	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	3	0	0	0	0	0	1	0
53	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
54	1	0	0	0	0	0	1	1	2	0	0	0	0	0	1	1	3	0	0	0	0	0	1	0
55	1	0	2	2	7	0	2	1	1	0	5	3	7	0	3	1	2	0	1	1	7	0	1	0
56	3	0	0	0	0	1	1	2	6	0	0	0	0	1	1	3	6	0	0	0	0	0	1	1
57	2	0	0	0	0	0	2	1	3	0	0	0	0	0	3	2	3	0	0	0	0	0	1	1
58	2	0	0	0	0	0	3	2	3	0	0	0	0	0	4	2	3	0	0	0	0	0	1	1
59	3	0	0	0	0	0	4	3	4	0	0	0	0	0	5	4	7	0	0	0	0	0	2	3
60	3	1	2	14	13	1	6	2	5	0	4	20	14	1	8	3	6	1	1	11	12	1	2	1
61	3	1	0	0	0	1	4	3	4	2	0	0	0	1	5	4	3	0	0	0	0	2	3	1
62	4	2	0	0	0	3	6	4	7	1	0	0	0	3	7	6	0	2	0	0	0	2	3	1
63	3	2	0	0	0	2	5	3	4	2	0	0	0	3	6	4	0	3	0	0	0	0	3	1
64	2	1	0	0	0	1	4	3	3	1	0	0	0	2	5	3	0	1	0	0	0	0	3	2
65	3	1	8	26	16	3	4	3	5	1	15	24	19	4	5	4	0	1	6	27	11	2	3	1
66	4	3	0	0	0	4	6	4	5	4	0	0	0	5	7	5	0	3	0	0	0	1	4	2
67	3	5	0	0	0	3	4	3	4	6	0	0	0	4	5	4	0	4	0	0	0	1	3	2
68	2	3	0	0	0	2	4	2	2	3	0	0	0	2	4	2	0	3	0	0	0	1	4	1
69	1	2	0	0	0	1	3	1	1	2	0	0	0	2	3	1	0	1	0	0	0	1	2	1
70	2	4	13	24	13	5	5	2	2	4	19	14	17	6	5	2	0	4	12	29	8	3	4	1
71	2	8	0	0	0	3	2	2	3	11	0	0	0	3	1	3	0	6	0	0	0	2	3	0
72	2	6	0	0	0	2	1	2	4	6	0	0	0	3	0	3	0	6	0	0	0	0	3	1
73	1	3	0	0	0	1	2	2	2	4	0	0	0	2	2	2	0	2	0	0	0	1	3	1
74	3	4	0	0	0	1	2	3	4	4	0	0	0	1	1	4	0	3	0	0	0	0	5	2
75	3	4	25	12	11	2	2	3	4	4	23	8	15	2	1	4	0	3	25	14	6	2	3	1
76	2	4	0	0	0	2	1	2	2	5	0	0	0	2	1	3	0	4	0	0	0	0	3	1
77	2	5	0	0	0	1	2	3	0	5	0	0	0	1	1	2	0	6	0	0	0	1	4	3
78	1	2	0	0	0	2	2	2	2	2	0	0	0	2	1	2	0	2	0	0	0	0	2	2
79	1	2	0	0	0	1	1	1	1	2	0	0	0	1	2	1	0	1	0	0	0	0	1	0
80	3	3	23	10	9	6	2	3	3	3	10	12	12	7	2	5	0	3	26	9	5	1	2	0
81	4	5	0	0	0	4	1	6	4	5	0	0	0	5	2	6	0	5	0	0	0	1	1	7
82	1	2	0	0	0	3	1	1	1	3	0	0	0	4	0	1	0	1	0	0	0	1	1	1
83	1	2	0	0	0	3	1	3	1	3	0	0	0	4	1	1	0	1	0	0	0	1	1	4
84	0	2	0	0	0	2	1	2	1	2	0	0	0	2	1	0	0	1	0	0	0	1	0	3
85	2	2	15	6	7	5	1	3	1	2	18	12	6	5	0	1	4	2	14	3	8	2	1	6
86	3	3	0	0	0	4	1	3	1	3	0	0	0	5	1	1	5	3	0	0	0	3	1	4
87	7	2	0	0	0	3	1	6	1	1	0	0	0	3	1	2	14	3	0	0	0	2	1	12
88	3	3	0	0	0	1	1	3	1	1	0	0	0	1	0	1	5	4	0	0	0	2	1	4
89	1	1	0	0	0	1	1	1	0	1	0	0	0	1	0	0	3	1	0	0	0	2	1	2
90	2	2	7	4	7	4	1	2	1	0	2	2	3	4	0	1	3	3	9	4	14	7	2	3
91	3	3	0	0	0	2	1	2	1	2	0	0	0	2	0	1	4	3	0	0	0	2	1	3
92	2	1	0	0	0	2	1	1	0	1	0	0	0	1	1	0	4	1	0	0	0	5	3	3
93	2	2	0	0	0	2	1	1	0	2	0	0	0	1	0	0	3	2	0	0	0	3	2	3
94	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2	1	0
95	0	1	4	1	4	2	0	0	0	0	3	1	1	1	0	0	1	1	4	1	8	7	1	1
96	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	3	1	0	0	0	4	1	3
97	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	4	1	1
98	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	3	1	1
99	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0
100	1	0	1	0	2	1	0	1	0	0	0	0	1	0	0	0	3	1	1	1	5	4	1	2
101	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	2	0	0	0	1	0	2
102	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
103	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	1	0	0	0	1	1	1
104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	2	0	0
106	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1	1
107	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	1
108	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
110	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	0	1
111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0